Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of: Establishment of a Model for Predicting Digital Broadcast Television Field Strength Received at Individual Locations	ET Docket No. 10-152

FURTHER COMMENTS OF DIRECTV, INC.

When the Commission established its most recent model for predicting whether a household is "served" by over-the-air digital television signals, it explicitly conceded that model's shortcomings.[1] In light of these shortcomings, and consistent with the statutory requirement that the Commission continually improve the model by use of additional data as it becomes available,[2] the Commission has requested information on "improving the degree to which the model accurately represents the propagation of a digital television signal."[3] Inaccuracy in the model, after all, has real-world consequences. Where today's digital Individual Location Longley Rice ("digital ILLR") model erroneously predicts a household to be "served,"

[1] *Establishment of a Model for Predicting Digital Broadcast Television Field Strength Received at Individual Locations*, Report and Order and Further Notice of Proposed Rulemaking, FCC 10-194, ¶ 35 (rel. Nov. 23, 2010) ("*Order*") ("[W]e remain aware and concerned that using the outdoor reception model may result in instances where a consumer who either cannot use an outdoor antenna or cannot receive service using an outdoor antenna and is not able to receive a station's service with an indoor antenna will be found ineligible for satellite delivery of a distant network signal.").

[2] *See Satellite Television Extension and Localism Act of 2010*, Pub. L. 111-175, 124 Stat. 1218 (2010), § 339(c)(3)(A) ("STELA") (the Commission shall "shall establish procedures for the continued refinement in the application of the model by the use of additional data as it becomes available.").

[3] *Order*, ¶ 58.

that household may end up with *no* access to network programming. As demonstrated by its directive to continually improve the predictive model, Congress found this to be an unacceptable outcome.

In order to implement the congressional mandate, the Commission has invited interested parties to submit proposals and suggestions for improving the digital ILLR model, including discussion of any new data that may be available for improving the model's predictions.[4] DIRECTV, Inc. ("DIRECTV") submits that the Commission should draw upon the methodology used by AntennaWeb.org ("AntennaWeb"), a website created by the National Association of Broadcasters ("NAB") and the Consumer Electronics Association ("CEA"), which uses an ILLR-based model to recommend an appropriate antenna for consumers seeking to receive over-the-air digital broadcast signals. Having created AntennaWeb, broadcasters have endorsed the predictive methodology employed by that website to give consumers real-world advice about whether or not they can receive over-the-air digital television signals. This advice, moreover, often conflicts with the predictions of digital ILLR. Thus, subscribers are often told that they cannot receive distant signals because the Commission's model predicts they will receive local signals only to discover that the NAB's more accurate model predicts otherwise.

AntennaWeb improves upon digital ILLR in two basic respects. First, AntennaWeb uses more highly detailed geographic and topographical data than does digital ILLR. Second,

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[4] *Id.* The Commission also seeks comment on proposed refinements to the model submitted by Sidney E. Shumate, president of Givens and Bell, Inc. Mr. Shumate's new model ("ITWOM") would replace the current line-of-sight loss calculation contained in the existing digital ILLR, and instead calculate the losses close to obstructions using a scientifically-based system using Snell's Law, Beer's Law, and a set of approximations of the Radiative Engine Transfer Functions to estimate clutter loss. *Id.* ¶ 16. While DIRECTV favors any approach that would improve the accuracy of the predictive model used to determine which households are "unserved," it believes that the approach discussed in these comments provides a more straightforward method for achieving this goal.

AntennaWeb makes adjustments to several factors used in the model related to location, interference, line loss, and the like to increase the model's accuracy and reliability. As anticipated by Congress, the Commission should incorporate this newer, more accurate data and modeling into digital ILLR.

I. AntennaWeb's Consumer-Friendly Design Provides More Accurate Results.

NAB and CEA created the AntennaWeb predictive model as a method of predicting whether a household could receive an over-the-air television signal using a variety of CEA-rated antennas.[5] Presumably, those two organizations perceived shortcomings with other then-existing models, including digital ILLR.

Because digital ILLR was championed by NAB and others with an interest in "protect[ing] the role of local broadcasters in providing over-the-air television by limiting satellite delivery of network broadcasting programming,"[6] one might naturally suspect that the model would tend to over-predict the ability of a given household to receive digital signals. In the STELA context, local broadcasters might find such inaccuracy acceptable (or even beneficial) even if it means that some consumers are thereby precluded from receiving broadcast network service from any source. But in helping consumers choose antennas that can actually receive over-the-air signals in the real world, however, NAB appears to have decided it needed a more accurate model.

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5 CEA publishes widely accepted standards for outdoor receiving antennas, which create color codes associated with minimum performance parameters. Consumer Electronics Association, CEA Standards – Standards Listed by Committee, Color Codes for Outdoor TV Receiving Antennas, http://www.ce.org/Standards/browseByCommittee_2533.asp.

6 Comments of the Broadcaster Associations, at 2, ET Docket No. 10-152 and ET Docket No. 06-94 (filed Aug. 24, 2010) (purporting to describe the "purpose of STELA and all its predecessors"); *see also Order*, ¶ 32 (expressing concern that changes in the digital ILLR model "would remove large numbers of viewers from local stations potential audience").

NAB and CEA's concern that existing models might over-predict the availability of digital signals was well founded. An analysis of AntennaWeb data for ABC, CBS, FOX, and NBC stations in three DMAs[7] shows that approximately 44% of DIRECTV subscribers are, with respect to at least one network, both (1) predicted by digital ILLR to be "served" by a local affiliate; and (2) predicted by AntennaWeb to be unable to receive any signal at all from that affiliate. Looking at the data in more detail, DIRECTV's analysis shows that the two models' predictions do not match with respect to one network for 23% of households; with respect to two networks for 8% of households; and with respect to three or four networks for 6% of households.[8] In other words, digital ILLR's predictions only match AntennaWeb's for just over half of the households (56%) in the three DMAs analyzed. The discrepancy between the two models is depicted in the graphics below. For each network in each of the three DMAs analyzed:

- **Yellow** dots represent households predicted able to receive over-the-air signals under both models.

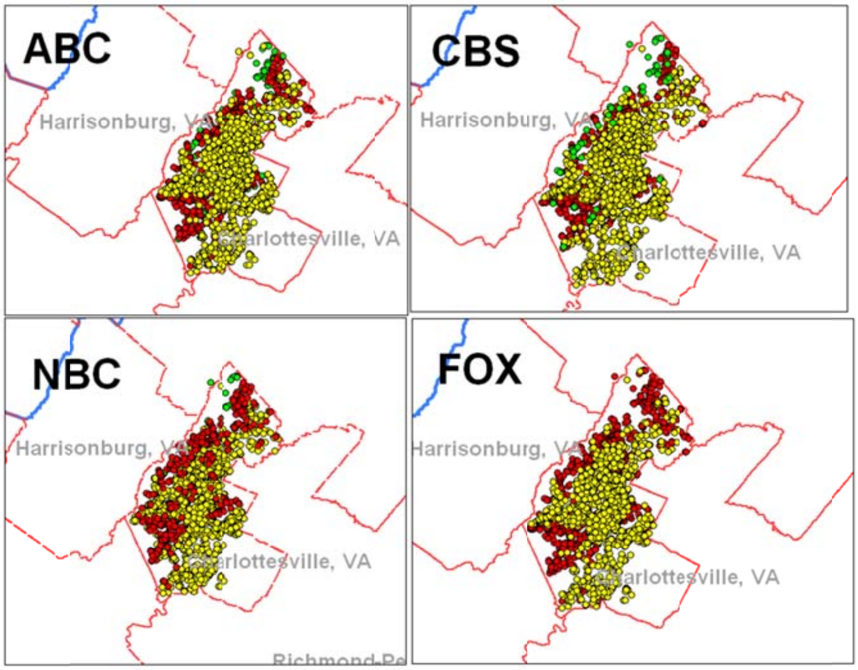
- **Green** dots represent households predicted unable to receive over-the-air signals under digital ILLR.

- **Red** dots represent households predicted able to receive over-the-air signals under digital ILLR, but unable to do so by AntennaWeb. These are the subscribers harmed by digital ILLR's inaccuracy.

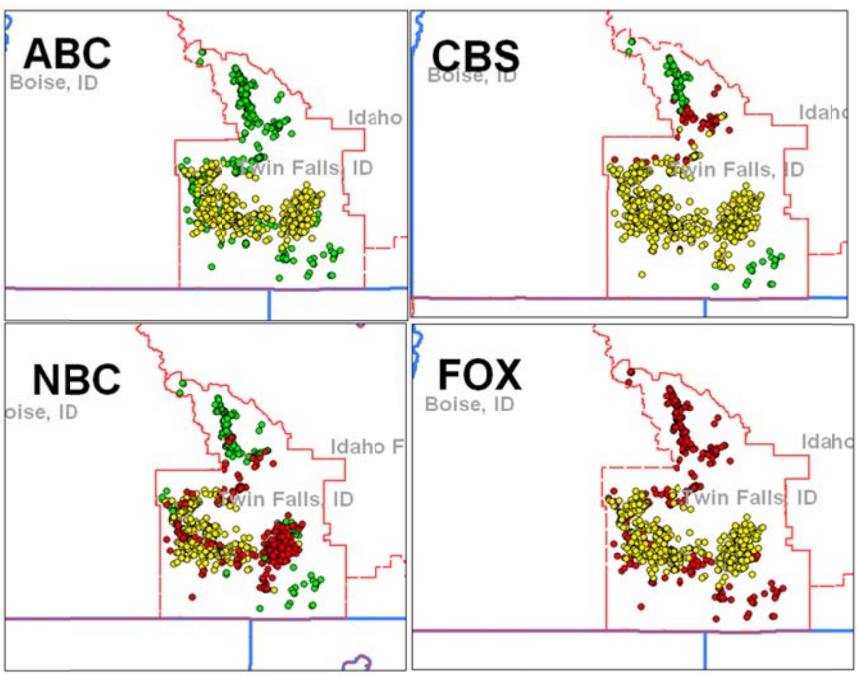
7 This data was generated by TitanTV, which powers AntennaWeb. The DMAs TitanTV looked at are Charlottesville, Virginia; Twin Falls, Idaho; and Grand Junction-Montrose, Colorado.

8 The amount of over-prediction of service varies greatly by market and by network. For instance, in the Twin Falls DMA, the discrepancy between digital ILLR and AntennaWeb is 0% for ABC, but is 20% for CBS. Similarly, in Grand Junction-Montrose, the discrepancy is 8% for ABC and CBS, but is 40% for FOX. At the fringes of a service area, though, AntennaWeb may indicate a difference in signal strength of up to 8 dB from the predictions made by ILLR.

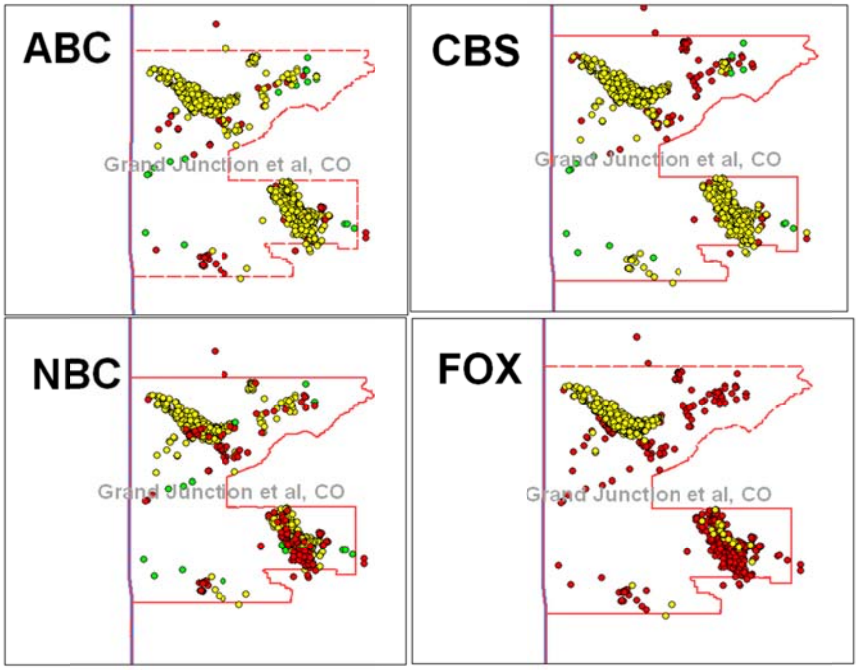
Charlottesville, Virginia:



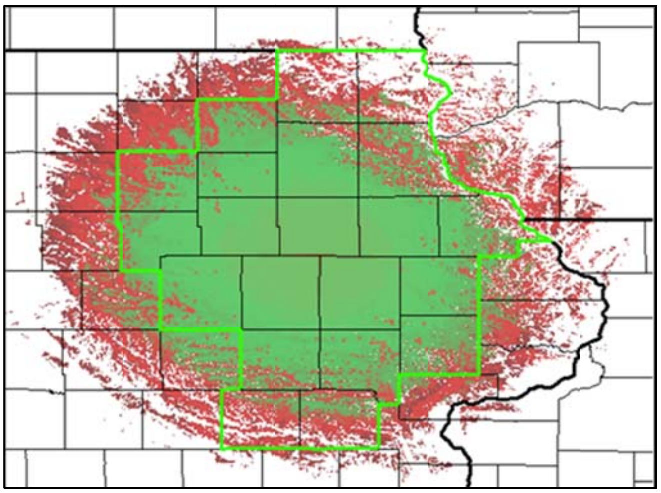
Twin Falls, Idaho:



Grand Junction-Montrose, Colorado:



One can also aggregate this data geographically to get a sense of the problem's extent. The graphic below depicts the difference between the signal contours predicted by digital ILLR and AntennaWeb for a single ABC affiliate, KCRG in Cedar Rapids, Iowa. Both models predict signal coverage within the area shaded green in the graphic. The areas shaded red indicate where digital ILLR predicts that households will be able to receive KCRG, but AntennaWeb predicts that households cannot do so with even the most powerful antenna.[9]



When subscribers in these areas contact DIRECTV seeking distant signals, it must tell them they are ineligible because they are predicted to receive over-the-air local signals through the use of "an antenna."[10] When they check the NAB-endorsed website to determine what sort of antenna will allow them to do so, however, they are told – accurately – that *no* antenna will

9 The most powerful antennas considered under the AntennaWeb model (those with a CEA color rating of "violet") are large, directional antennas. These antennas have multiple elements and are appropriate for receiving all signals predicted for a given address, including those that are predicted to be the weakest at a given location. They must be roof mounted and require an amplifier to receive those weaker signals. *See* AntennaWeb, Large Directional Antenna, http://www.antennaweb.org/aw/antenna.aspx?color=Violet.

10 17 U.S.C. § 119(d)(10)(A).

suffice. The Commission's predictive model should no longer confuse and frustrate consumers in this way.

II. The Commission Should Incorporate AntennaWeb's More Accurate Geographical Databases.

One fundamental difference between digital ILLR and AntennaWeb relates to data used to assess the terrain between the broadcasting television station and the household at which signal strength is predicted. First, AntennaWeb uses higher-resolution United States Geographical Survey ("USGS") maps than does the digital ILLR Model. Digital ILLR employs USGS maps that were sampled at 3.5 arcminutes, or approximately every 90 meters. But AntennaWeb uses USGS maps that were sampled at 1 arcminute, or approximately every 30 meters. AntennaWeb's data therefore has nine times the density of that used by the Commission.

Second, AntennaWeb uses another source for land use and land clutter information: topographical maps from NASA's shuttle radar terrain mapping project.[11] Unlike USGS, which used paper maps to compile its topographical data, NASA collected elevation data with radar. Its maps therefore indicate anything on the ground that returns a radar signature. In many respects, this creates a more accurate representation of the obstructions a TV signal actually encounters when travelling from a transmitter to an individual household. For instance, the radar maps indicate tall buildings and tree coverage that can cause interference that would not otherwise be predicted based on elevation alone. (We understand that newer, even more accurate data from a more recent shuttle mission may be available.[12])

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[11] The radar mapping shuttle mission took place in 2000. *See* Shuttle Radar Topography Mission, http://www2.jpl.nasa.gov/srtm/ (last updated June 17, 2009).

[12] *See* NASA, NASA, Japan Release Most Complete Topographic Map of Earth, June 929, 2009, http://www.nasa.gov/topics/earth/features/aster-20090629.html.

Third, AntennaWeb differs from digital ILLR in terms of accounting for elevation. Digital ILLR samples the elevations among the four grid points closest to a location. This can cause what is known as height and shadow "smoothing" as extreme differences in height (and the impact such differences have on reception) are averaged out for particular geographical coordinates. Because AntennaWeb's topographical data has a much higher resolution, it simply chooses the elevation of the closest grid point to a given location. This means that, in areas of variable elevation, ILLR will systematically tend to ignore interference while AntennaWeb will more accurately account for that interference.

By using higher-resolution geographical information as well as radar maps that more precisely indicate sources of interference, AntennaWeb is able to make more accurate predictions of which locations will be able to receive digital television signals. Upgrading data used in the model will better ensure that consumers who legitimately cannot receive over-the-air broadcast television signals are not denied access to marquee network programming due to inaccurate predictions. The Commission should incorporate this additional and improved data into its digital ILLR model.

III. The Commission Should Incorporate AntennaWeb's Parameters and Planning Factors to Increase the Accuracy of Digital ILLR.

In addition to using more detailed and current data, AntennaWeb also uses different parameters and planning factors to increase the accuracy of its predictions as compared to digital ILLR. NAB has in the past opposed proposals to incorporate more substantial adjustments to these planning factors into digital ILLR, and the Commission has rejected them on the basis of that opposition. NAB's use of somewhat more modest adjustments in AntennaWeb, however, suggests that, at least in certain combinations, such adjustments lead to better predictions. The Commission should incorporate them into digital ILLR as well.

First, AntennaWeb employs a more realistic location variability factor than does digital ILLR. As the Commission noted, the field strength of radio signals (including television signals) at a given distance from a transmitter vary by location and with time due to factors affecting their propagation.[13] The Commission recently adopted F(50, 90) time and location variables, which were derived from "an industry-Government consensus that relied on the traditional TV service model."[14] This means that "at least 50% of locations (at the edges of the station's service area) will receive a signal of the required strength at least 90% of the time."[15] By contrast, AntennaWeb uses a 90 percent location variability factor (*i.e.*, F(90, 90)), meaning that at the edge of the station's service area, at least 90% of locations would receive the required strength at least 90% of the time.[16] The 90 percent location variability thus results in fewer over-predictions of service compared to digital ILLR.

The Commission recently rejected satellite industry proposals to increase both the time *and* location variables to 99 percent. The Commission did so because it concluded that it would be unrealistic to require the non-linear technical improvements necessary to approach 100 percent availability and that the significant reduction in the predicted local DTV service area would not reflect the ability of most viewers to receive over-the-air signals.[17] These concerns would not apply to the more modest changes contained in the AntennaWeb model, changes that NAB itself has endorsed through implementation.

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[13] *Order*, ¶ 37.

[14] *Id.* ¶ 42.

[15] *Id.* ¶ 38.

[16] *Antenna Recommendation Algorithm for ATSC Transmitters* at 2, attached hereto as Exhibit A ("*AntennaWeb Technical Paper*").

[17] *Order*, ¶¶ 41-42.

Second, AntennaWeb takes into account several sources of interference ignored by digital ILLR. These include:

- Dipole factor
- Dipole factor adjustment
- Thermal noise
- Receiver noise figure
- Line loss
- Splitter loss
- Effective preamplifier gain
- Antenna gain
- Multipath margin, if applicable
- Minimum carrier-to-noise ratio.[18]

The Commission itself has recognized that failing to account for at least some of these factors reduces the reliability and accuracy of digital ILLR. For example, with respect to multipath interference, the Commission recognizes that "the presence of other signals on the same or adjacent channels does have the potential for disrupting service."[19] It previously concluded, however, that "the effects of other signals are a separate matter from the basic functioning of a receiver in an interference-free environment that forms the basis for the Commission's field strength standards"[20] and that multipath interference is too difficult to calculate in individual circumstances.[21] But NAB and CEA were able to develop mechanisms for addressing these concerns in creating the more accurate AntennaWeb model. The Commission should adopt a similar approach.

In its most recent proceeding on the predictive model, the Commission raised concerns about adjustments proposed by the satellite industry, especially those adjustments proposed to

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[18] *AntennaWeb Technical Paper* at 4.

[19] *Order*, ¶ 19.

[20] *Id.*

[21] *Id.* ("[T]he incidence of multipath varies significantly over very short distances and the level of multipath and its character is generally not a predictable factor.").

account for indoor reception issues. Those concerns are not relevant to the methodology used by AntennaWeb, which (like digital ILLR) presumes the use of an outdoor antenna. Thus, there is no risk that consumers could take the "easy path" to distant signal qualification by reporting that they cannot use an outdoor antenna, as the Commission feared in the prior context.[22]

Moreover, such adjustments would not "alter the digital television service description as defined in the Section 73.622(e)(1) signal strength standard"[23] or create inaccuracy by assuming different conditions for reception than "the assumptions underlying the signal strength needed for reception as described by the standard."[24] Adjustments such as those endorsed by NAB are not changes to the signal strength levels themselves; rather, they help more accurately predict whether particular equipment can receive signals at those levels. Arbitrarily demanding that planning factors must always be the same as those used to create the broadcast contours in the first place would preclude improvements to the predictive model and greatly reduce the accuracy of such a model when applied to real-world equipment, contrary to the explicit mandate of Congress.

IV. Conclusion

The Commission is required by statute to improve the accuracy of its predictive model and to incorporate additional data as it becomes available.[25] DIRECTV therefore urges the Commission to adopt the higher-resolution and more current geographical databases used by AntennaWeb, as well as the variety of planning factors in the AntennaWeb algorithm, to more accurately predict signal interference. These adjustments and improvements to digital ILLR

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22 *Id.* ¶ 32.

23 *Id.*

24 *Id.* ¶ 31.

25 STELA, § 339(c)(3)(A).

have been endorsed by NAB itself. In addition to rendering the model more accurate, they will also ensure appropriate access to network programming for those consumers who are currently without any means of receiving an over-the-air broadcast signal.

Respectfully Submitted,

/s/

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EXHIBIT A

Antenna Recommendation Algorithm for ATSC Transmitters

Ken Franken
Decisionmark Corp.
1/13/04 – (modified UHF system noise figure)
6/15/06 – (revised to match new data and algorithm)
3/15/07 – (revised to clarify multipath algorithm for directional and non-directional antennas)

Overview

The Antenna Recommendation algorithm recommends a class of receiving antenna optimized for a specific location and set of installation options.

The sections below describe the preparation of obstructions data, terrain data and the runtime algorithm for recommending a specific antenna for ATSC reception.

Preparation of Obstruction data

1) Import buildings/obstructions data into an obstructions database. All points to be classified as buildings, towers, TV transmitter towers, FM transmitter towers, elevators, tanks, or temporary structures. Where available, include obstruction radius, otherwise mark as NULL. Unless otherwise noted below, the data is current as of spring 2006. Data used includes:

- FAA Digital Obstructions File (DOF)
- FCC Antenna Obstructions Registration database (ASR)

2) Adjust coordinates to NAD 83 as necessary to match the datum used by the terrain elevation database and the antenna technical database.

3) Filter obstructions database. Remove:

- Buildings, control towers, cooling towers, elevators, tanks less than 12.2 meters (40 feet) tall
- Transmitter towers less than 18.3 meters (60 feet) tall
- Temporary structures

4) Reclassify all obstructions within 100 meters of a TV or FM transmitter as a TV tower. This is done in order to avoid “double counting” multiple transmitters on a single tower. Note that as a side effect of this step, these obstructions will not cast a shadow -- TV transmitters are not considered under the terrain elevation augmentation.

5) Update NULL object radius based on height:

Height (meters)	Radius (meters)
< 30	34.38
30 – 60	54.02
60 – 90	60.88
> 90	69.71

6) Create runtime version of filtered obstructions database that can be read by the signal strength prediction program.

7) At runtime, generate a list of all obstructions within 8.45 kilometers of the receiver (this is 13 times the height of the tallest entry in the database). Exclude all obstructions within 3.22 kilometers (2 miles) of the transmitter site. This list is used to determine obstruction-dependent

multipath areas using the procedure outlined in the *Multipath Calculation – Obstructions* section below.

Preparation of Terrain data

Terrain data is produced from a pair of elevation databases. The first database is the USGS one arc second DEM database; the second database is the one arc second SRTM database, derived from shuttle radar mapping. The data was prepared as follows:

1) Augment the USGS terrain elevations with obstruction heights from the filtered obstructions database. Use object radius from the filtered database. Exclude all obstructions within 3.22 kilometers (2 miles) of the transmitter site. Include the following obstruction types:

- Buildings
- Elevators
- Tanks

2) Combine the augmented USGS elevations from step 1) with the SRTM elevations to form a combined elevation database. The elevations in this combined database are calculated as the maximum of the augmented USGS elevation and the SRTM elevation.

3) At runtime, generate a terrain elevation profile using the combined elevation database from step 2). Use a spacing of 30 meters between points. "Snap" each profile point to the closest grid point in the database. Replace the reception elevation with an elevation taken from the augmented USGS database from step 1). This gives an elevation profile that includes obstructions (from the obstructions database and from radar-reflective obstructions included in the SRTM data), but places the reception point at its true elevation.

Outline of the Antenna Selector Algorithm (Digital Transmitters)

1. Geocode the user-supplied address.
2. Calculate reception height above ground based on user-supplied Housing Type data [single story = 6.1 meters (20 feet), multistory = 9.1 meters (30 feet)] or use a user-supplied reception height, if specified.
3. Calculate ILLR field strength predictions for the geocoded location using the ILLR server. Use 90/90 time/confidence factors for ATSC transmitters. Use Decisionmark Coronado database, updated bi-weekly, for transmitter technical data. Use obstruction-augmented USGS terrain elevations, prepared as described above.
4. Use plain trigonometry with the ILLR terrain elevation path to determine whether a line of sight exists between the transmitter and the receiver.
5. Set an obstructions flag to TRUE if user indicated nearby structures or airport, or if the geocoded location falls within an obstruction multipath region, as defined in the *Multipath Calculation* section below, or if there is no line of sight as calculated in step 4).
6. Use the above factors and the R5 planning factors to calculate power margin for each type of antenna, with and without pre-amplifier, as defined in *Power Margin* section below.
7. Select the antenna with the smallest power margin >= 0 dB, returning the appropriate antenna color code. [See *Color Codes* below].

Details of the Antenna Selector Algorithm

Multipath Calculation

Multipath effects are assumed to exist if any of the following conditions apply:

User Input
The AntennaWeb site asks the user whether there are any structures taller than four stories within four blocks of the location, nearby trees over 30 feet high, or if there are any major airports within two miles of the location. If the user answers “Yes,” assume that the location is in a multipath region.

Line of Sight
Assume multipath conditions apply if there is not a trigonometric line of sight between the transmitter and the receiver (using augmented terrain elevations).

Obstructions
Obstructions set up a region of multipath interference. The size and shape of this region is dependent on the height of the obstruction and the geometry between the receiver, transmitter and obstruction. We will identify multipath regions as the area within 2 x's the height of the obstruction, or the area within 13 x's the height of the obstruction and within 70 degrees of the line between the transmitter and the obstruction, as shown in Figure 1.

Margin
In areas with multipath effects, we assume that non-directional antennas require an extra signal margin in order for the receiver to be able to distinguish the desired signal from multipath artifacts. The Mutipath Margin is applied to non-directional antennas whenever a multipath effect is predicted due to user input, line of sight or obstructions as detailed above.

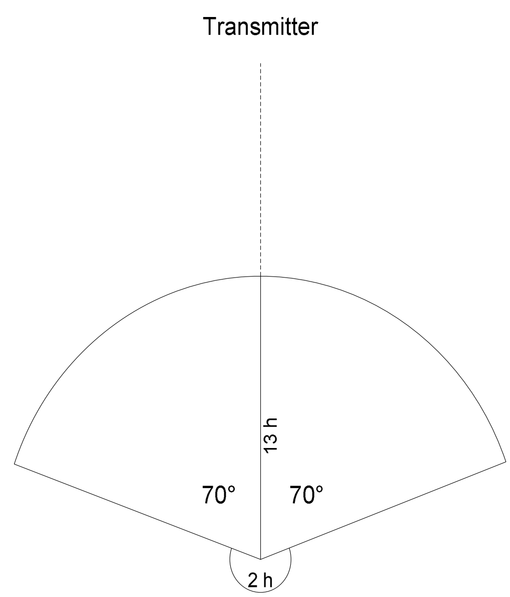

Figure 1

Multipath region around obstructions

Power Margin

Power margin represents the "excess" capacity of a given reception system as a function of predicted field strength (ILLR), fixed planning factors and location-specific planning factors. Power margin is calculated using the planning factors below and the equation:

$$\text{Margin} = \text{ILLR} + K_d + K_a + G_a + G_p - N_t - N_r - L_l - L_t - M_m - C/N$$

Planning Factor	*Abbreviation*	*low VHF*	*high VHF*	*UHF*	*Notes*
Dipole Factor	K_d	-111.8	-120.8	-130.8	
Dipole Factor Adjustment	K_a	0	0	20 log(615/f)	f is the channel mid-frequency in MHz
Thermal Noise	N_t	-106.2	-106.2	-106.2	
Receiver Noise Figure	N_r	10	10	10	
Line Loss	L_l	1	2	4	
Splitter Loss	L_t	6.5	6.5	6.5	
Effective Preamplifier Gain	G_p	8.6	8.9	9.8	If applicable. See Color Code table below.
Antenna Gain	G_a	*	*	*	See Color Codes table below
Multipath Margin	M_m	12	12	12	If applicable. See *Multipath Calculation* above.
Minimum Carrier to Noise Ratio	C/N	17.5	17.5	17.5	

Color Codes

Selection of a color code is done using the power margin, as calculated above, and the multipath flag: the recommended color code for non-multipath regions is the one with the smallest positive power margin. For multipath regions, we restrict this to directional antennas.

antenna size	*directional*	*preamp*	*low VHF gain*	*high VHF gain*	*UHF gain*	*effective preamp gain*	*color code*
small	no	no	-25	-15	-10	n/a	yellow
medium	no	no	-12	-9	-6	n/a	green
large	no	yes	-4.5	-4.5	-4.5	see above	light green
medium	yes	no	-2.5	0	0	n/a	red
medium	yes	yes	-2.5	0	0	see above	blue
large	yes	yes	4	6	8	see above	violet